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(54) **Title:** TRANSMISSION SYSTEM FOR SYNCHRONOUS AND ASYNCHRONOUS DATA PORTIONS

(57) Abstract

In a transmission system for transmitting synchronous data portions and asynchronous data portions, the transmission frame comprises regularly spaced synchronous data portions inverleaved with asynchronous data portions. A problem in such a transmission system is that the packing density of asynchronous data portions is not optimal. According to the inventive concept, the position of the synchronous data portions is allowed to deviate from its nominal value to increase the packing rate of the asynchronous data portions.

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Transmission system for synchronous and asynchronous data portions.

The invention is related to a transmission system comprising at least one transmitter coupled to at least one receiver, said transmitter comprises frame assembly means for assembling frames from synchronous data portions and asynchronous data portions, the transmitter further comprises transmitting means for transmitting the frames to at least one receiver.

The invention is also related to a transmitter, a receiver, a transmitting method and a signal to be used in the above mentioned transmission system.

Such a transmission system is known from US-A 4,914,650.

In the future communication systems may converge to a single network by which all subscribers are interconnected. Such network must be suitable for transmission of signals required for applications such as telephony, digital TV, and data communication. All these applications require different types of services from the network. Telephony requires a low delay low bitrate connection. Digital TV transmission requires a substantial higher bit rate but tolerates a larger delay. Data traffic is generally quite bursty and has delay requirements strongly dependent on the type of user application it is used for.

In order to deal with all these requirements the transmission system known from the above mentioned US patent is arranged for transmitting a signal having fixed positions reserved for synchronous data portions. The remaining space in the signal is available for asynchronous data portions are often constituted by a plurality of packets, such as an ATM cells having a 5 byte header and a 48 byte payload area. In the prior art system an integer number of packets has to be placed between two subsequent synchronous data portion, which can result in same unused space.

It is an object of the present invention to provide a transmission system according to the preamble in which the amount of unused space in the transmitted signal is reduced.

Therefor the transmission system according to the invention is characterized in that the frame assembling means are arranged to insert the synchronous data at positions differing from their nominal positions in order to increase the efficiency of placing the asynchronous data in the frames.

By allowing the position of the synchronous data portions to be different

from their nominal position, the amount of unused space can be reduced. The position of the synchronous data portions are chosen in an adaptive way to minimise the unusual space. In order to inform the receiver about the position of the synchronous data portion, an indication of their position can be transmitted at the beginning of a frame. Alternatively it is possible to provide the synchronous data portions with an identifier allowing the receiver to recognise them.

An embodiment of the invention is characterized in that the frames comprises a plurality of elementary data cells, in that the synchronous data portions are carried by a first integer number of elementary data cells, and in that the asynchronous data portions are carried by a second integer number of elementary data cells.

By splitting the asynchronous data portions into an integer number of elementary data cells, it becomes possible to decrease the unused space portions even more, because now the asynchronous data portions can be broken up to allow the transmission of a synchronous data portion in between.

The invention will now be explained in more detail with reference to the drawings. Herein shows:

Fig. 1, an embodiment of a telecommunication network in which the invention can be applied;

Fig. 2, the interconnection between the head end 1 and a subscriber station 8, 10, 12;

Fig. 3, the hierarchical construction of the frames used in the present invention;

Fig. 4, a frame structure according to the prior art transmission system.

Fig. 5, a frame structure according to the present invention.

Fig. 6, a flow diagram of a program to be used in the processor in the transmitter according to Fig. 2.

In the CATV system according to Fig 1 using the hybrid fibre coax architecture, which basically comprises a head end 1, a trunk network (often using optical fibre), a plurality of local nodes 3,5,7,9, a feeder network (coaxial cable) and the drop network. The trunk network often uses optical transmission technology, but the present invention is not limited thereto. The trunk network 2 connects the head-end 1 with the local nodes 3,4,5,7 and 9. The feeder network connects the local nodes with the end-amplifiers 6, 14, and the drop network connects the end-amplifiers 6,14 to the subscribers 8,10,12. Currently an average 500 subscribers are served by one local node. It is clear that in the near

future even less subscribers are served by the same local node. The number of subscribers per local node decreases approximately a factor of two each year. The amplifiers in the feeder network are two-way amplifiers, with a return channel that is shared among the subscribers.

The network described before is a tree-and-branch topology and therefore will always have single points in the root of the tree (e.g. the head-end) as shown in Figure 1. This means that the central point can also be used for processing the protocols centrally instead of in a distributed way.

This simple observation has important consequences for the system. The main advantage of this approach however is the increased flexibility of the system. In the network described above the nodes in the network have to signal to the central point that they want some bandwidth, but the consequent processing of those requests and the allocation of bandwidth to a node is done centrally. So the terminals only have to know how the requests are transmitted and not how to deal with the requests. In this concept the Network Interface Units (NIU's) are slaves from the Network Access Control Node (NACoN).Most protocols such as the MAC protocol for obtaining access to the transmission medium can be implemented if the framing is properly defined. Using this approach it is necessary to define the frame structure, but it is not necessary to define the protocol in the same way as it is traditionally done for LAN or MAN networks. This document describes the frame structure and the functionalities that are necessary for standardization, so that an open system is defined that can be installed on operational and future networks. It can support a variety of MAC protocols so that depending on the class of services that the operator wants to offer an optimal MAC protocol can be chosen.

The head end according to Fig. 2, comprises servers 16 which are connected to a transmitter 17 which comprises a frame assembler 19 and transmitting means 20. In the present system separate downstream channels are used for medium-speed and high-speed data. It is however possible that the high-speed and medium-speed data is multiplexer for transmitting it. The head end 1 can be separated into two parts. The first part is the High-Speed Unidirectional part being intended for broadcast. It includes the transmitter 17 with the frame assembler 17 and the transmitting means 17 also called Broadcast Network Access Control Node (BNACoN) in the head-end 1 and the receiver 32 at the subscribers premises. The receiver 29 with the receiving means 32 and the frame disassembler 31 is also called Broadcast Network Interface Unit (BNIU) . Said first part is unidirectional and uses high-speed modulation, up to around 40 Mbit/s.

The second part is the Medium-Speed Bi-directional part. This includes the transmitter 22, with the frame assembling means 15 and the transmit means 22, and the receiver 24 in the head end 1. The combination of the transmitter 22 and the receiver 24 constitute the Interactive Network Access Control Node 21 (INACoN). The subscriber station 8, comprises an Interactive Network Interface Unit 34 (INIU). It has symmetric bi-directional capabilities, up to a few Mbit/s due to the presence of the transmitter 38 and the receiver 34, with the receive means 36 and the frame disassembling means 37. Most of the symmetric telecommunications connections (e.g. telephony, videophony and videoconferencing) as well as interactive control and computer traffic pass through this part. The data passes over the local access communications system over to the subscribers home, where various home appliances can be connected for their communication needs. Examples of such appliances include the Interactive Video Decoder 40, a personal computer 42 or a telephone 44. Again, these appliances can either pass through a single central node, as shown, or even use separate modems for each apparatus, before in-house wiring integration takes off.

In order to be able to transmit and receive all these different kinds of signals over a single physical medium, the head end 1 comprises a duplexer 26 and the subscriber station 8 comprises a duplexer 30.

As described in the introduction, the network has to deal with different traffic types depending on the applications supported. The net bit rates of the system are 1.544 Mbit/s or 2.048 Mbit/s (T1/E1 respectively) in order to support STM services like e.g. telephony as well as ATM services for e.g. data communication or control information for video on demand like services. A 256 kbit/s fall-back rate is also possible for cases in which the channel is excessively bad.

A possible modulator/demodulator design that is used in the transmit means 20 will be based on differential QPSK modulation with an efficiency of about 1.5 bits/s/Hz. The downstream transmission will be continuous, while the upstream will be in bursts. Due to the lay out of an hybrid fibre coax network (tree-and-branch network) where the loop length and attenuation between subscriber and head-end differ per subscriber both time ranging, power ranging and some kind of medium access protocol have to be implemented to facilitate efficient and reliable communication via the upstream channel.

The quality of the return path is lower than that of the broadcast path. Therefore, the modulation used by the transmitter 38 for the return path is a differential QPSK. The shaping filter is a Nyquist with a roll-off of 35%. The downstream path uses

QPSK with a DVB-like scrambling. Basically, in both directions the raw bit rate is either 1.737 Mb/s or 2.304 Mb/s to support T1/E1 respectively. Considering, the asymmetric transmission due to the 2-way electronic amplifiers with a narrow band for the return path and a large band for the broadcast path, the frequency ranges that might be encountered. The exact frequency range to be supported is 5-65 MHz for the upstream direction, and 47-860 MHz for the downstream direction. For systems up to around 2.5 Mbit/s, the channel is sufficiently flat, so that no equalization is needed. For higher bit rates, some equalization might be necessary. In this case, an additional equalization step might need to be performed at initialization.The variation in power is assumed to be less than 40 dB in the upstream direction.

In Figure 3 a general lay out of the frame structure is shown. It is assumed that the general frame structure is similar in the upstream and downstream direction. At the bottom of the frame hierarchy we have the so-called mini-cells, which are built up from X bytes. A cluster of M mini-cells forms a basic frame (BF). At the top of the frame structure we have the so-called multi-frames. A multi-frame contains B basic frames.

In Fig. 4 it is shown how two different classes of data, viz. system data and payload data can be carried in one basic frame. Within each class there is again a subdivision in cell types. In the system data we find mini-cells for synchronisation, ranging, housekeeping and MAC-protocol. In the payload class we distinguish mini-cells for Synchronous Transfer Mode (STM) services and mini-cells for all other sorts of services. These other services will all be based on Asynchronous Transfer Mode (ATM). Since in general an ATM-cell is larger than a mini-cell, an ATM-cell will be mapped into a train of consecutive mini-cells. The distribution of the various cell types can differ per basic frame and is fully controlled by the head-end. The amount of mini-cells allocated for housekeeping, ranging, MAC-layer and payload is adapted to the actual needs and can even be zero for some cell types. Therefore, the frame structure must not be seen as a rigid structure, but more as a virtual structure to facilitate an easy implementation of multiple services. There is a correspondence, however, between the downstream and the upstream structure. A multi-frame with a repetition rate of B basic frames makes it easier to "address" a specific basic frame. This addressing facilitates implementation of for instance ranging, very low bit rate STM services, and a flexible use of MAC cells in relation to delay requirements.

The system can operate in two modes, viz. a mode where there is no jitter on the STM data as is shown in fig. 4, and a mode where a certain amount of jitter on STM data is allowed as is shown in Fig. 5. The latter mode allows a more efficient mapping of

mini-cells for other, non-STM services within a basic frame. In the no-jitter mode it is possible that for a certain STM capacity there might not fit an integer number of ATM cells in the remaining interval between two successive STM blocks. This will cost a certain amount of ATM-bandwidth. By allowing an amount of jitter on the position of the STM-cells in the frame, we can pack the frame as tightly as possible.

The general frame structure can be described by a few parameters:

M	Number of mini-cells per basic frame
K	Number of STM blocks per basic frame (M/K must be a integer)
M_{ATM}	Number of mini-cells used to store an ATM-cell
N_{ATM}	Number of ATM-cells per cluster
M_{MAC}	Number of mini-cells for MAC per cluster
M_{Sys}	Number of mini-cells for system purposes (HK, ranging, sync) per basic frame
M_{STM}	Number of mini-cells per STM block
Mode	Operation mode: no-jitter on STM / jitter allowed on STM
delta	The maximum extra delay in mini-cells of an STM block in jitter mode compared to the corresponding STM block in the non-jitter mode. This parameter is only meaningful if jitter allowed on STM. If delta is made equal to 0, the non-jitter mode is obtained.

In general the downstream basic frames will start with a STM data block followed by a number of ATM/MAC-clusters. An ATM/MAC-cluster is a cluster of M_{clus} mini-cells formed by $M_{ATM} \cdot N_{ATM}$ mini-cells containing N_{ATM} ATM-cells followed by M_{MAC} mini-cells with MAC information. This pattern is repeated up to the end of the basic frame. The MAC part is used to broadcast mini-cell allocation information for upstream traffic to all subscribers and possible commands for collision resolution algorithms. The downstream basic frames will end with the system data such as sync words and housekeeping. Sync information is present at regular intervals in a multi-frame, so not necessarily in every basic frame. Housekeeping contains all physical layer data (ranging offsets, power settings, alarms etc) to keep the system running. The total amount of ATM/MAC clusters per basic frame in the non-jitter mode is equal to:

$$C_{cluster} = (K-1) \cdot \left\lfloor \frac{M/K - M_{STM}}{M_{ATM} \cdot N_{ATM} + M_{MAC}} \right\rfloor + \left\lfloor \frac{M/K - M_{sys} - M_{STM}}{M_{ATM} \cdot N_{ATM} + M_{MAC}} \right\rfloor \qquad (1)$$

It goes without saying that $M/k - M_{sys} - M_{STM}$ is larger or equal to 0, because otherwise the

system minicells and the STM minicells would not fit into the STM block. In this (non-jitter) mode there are K almost identical sub-frames in a basic frame. Each sub-frame starts with a STM block of M_{STM} mini-cells, followed by $C_{cluster}$ ATM/MAC-clusters. The remaining mini-cells in the sub-frames are used for MAC, except for the last sub-frame where also a part is used for system purposes (HK, ranging etc).

In the jitter mode the amount of ATM/MAC-clusters per basic frame is equal to:

$$C_{cluster} = \left\lfloor \frac{M - M_{sys} - K \cdot M_{STM}}{M_{ATM} \cdot N_{ATM} + M_{MAC}} \right\rfloor \qquad (2)$$

In the jitter mode a basic frame starts with an STM block. This block is followed by $C_{cluster}$ ATM/MAC-clusters. However, at intervals of about M/K mini-cells an STM block is put in between. The STM blocks can be placed within a ATM/MAC-cluster, but only at boundaries of ATM-packets. The STM blocks are positioned such that there is a maximum jitter compared with the start of a basic frame of $\pm \lfloor M_{ATM}/2 \rfloor$ mini-cells. The basic frame ends with the system data.

This approach requires that either every mini-cell contains in its header a cell-type identifier or that a certain number of mini-cells contain information concerning the mapping of cell types per frame.

The frame structure for both the upstream and downstream direction is similar. The cell mapping for an upstream frame is broadcast to all subscribers such that all subscribers know which mini-cells they may use and for which purpose. If there are some mini-cell locations not allocated due to improper spacing, they will be used for ATM or MAC.

The upstream frame needs no sync information but can have some space reserved for ranging purposes. Furthermore there can be mini-cells allocated for housekeeping which can be used in this case for acknowledgments of received housekeeping commands, monitoring functions, alarms etc. A part of the frame is reserved for the MAC layer, i.e. space where requests for bandwidth can be placed. The remaining part of a frame can be used for payload of various services. Again, like in the downstream direction, the amount of mini-cells allocated for a certain functionality can differ per basic frame and might be zero for some cell types.

The flowchart according to fig. 5 represents a program intended to run of a programmable processor in order to realise the frame assembling means. The flowchart

according to fig. 5 describes one of the possible algorithms using jitter and non jitter mode for mapping different cell types in a basic frame. First some of the The parameters used in the flowchart have the following meaning:

Y=M/K: the number of mini-cells between two successive STM blocks in an ideal no-jitter case.

ref: the ultimate start position of the next STM block. This ultimate start position is expressed in the number of minicells from the beginning of the frame.

offset: start position of a new cluster of cells of a certain type, e.g. start of STM block, start of ATM cluster, start of ATM-cells, start of MAC cells or start of HK-cells. Again this start point is expressed in a number of minicells from the beginning of the frame.

i_block: counter, 0, 1, ..., K-1. This counter indicates the number of the actual STM block.

i_atm: number of ATM cells of a splitted ATM cluster which are placed before the next STM block.

i_mac: number of MAC cells of a splitted ATM cluster which are placed before the next STM block.

A frame starts with a STM block. In instruction 50 a number of variables are initialised. The ultimate start position for the next STM block is calculated with the parameter ref. This parameter is initialized with delta, (delta >= 0), indicating the maximum delay (in mini-cells) that is allowed compared with an ideal no-jitter situation. In instruction 50 the variable i_block is set to 0 to indicate the beginning of the frame. The variables i_atm and i_mac are set to Natm and Nmac to indicate that in principle all ATM blocks and MAC blocks are to be placed before the next STM block. Finally in instruction 50 the number Mclus of minicells in an ATM/MAC cluster is calculated.

In instruction 51 the value of the counter i_block is compared with K. If I_block is equal to K the construction of the present frame is finished, and the program is terminated by the execution of the instruction 53.

Every time a new STM block is placed, "ref" is incremented with "Y=M/K" in instruction 54. The parameter "offset" is first incremented with the size of an STM block "Mstm" in instruction 54. Then it is incremented with the remaining number of ATM-cells ((Natm-i_atm)*Matm) and remaining MAC cells (Mmac-i_mac) from a splitted ATM cluster. In instruction 55 it is checked whether current block is the final block of a frame. If this is the case the variable "ref" is decreased with Msys in order to make

space available for the system information (HK, ranging, sync. in Fig. 4 and 5) Next the algorithm fits in as many ATM/MAC clusters as possible (determined by the value of "ref"). It increments in instruction 58 the parameter "offset" with Mclus until no complete new ATM/MAC-cluster fits in (offset+Mclus<ref; checked in instruction 57). The next ATM/MAC cluster is split. First the program tries to place as many ATM cells from this cluster as possible. This is done in the instructions 59 and 60. In instruction 59 it is checked whether there is space for another ATM cell by comparing "offset+Matm" with "ref". In the case all ATM cells could be placed, the remaining gap is filled with as many as possible MAC cells. Then it places the STM block and the whole procedure is repeated.

In instruction 61 it is checked wether the last segment of a frame is to be placed. If this is the case, the parameter "ref" is decremented with "delta" in instruction 62, and at the termination of the program in instruction 53 the variable "offset" is incremented with "Msys". The reason for these instructions is that a frame has to end properly and that in the last segment of a frame also the HK-cells are placed.

In instruction 63 it is checked whether all ATM cells of the current ATM/MAC cluster are placed or whether the final block has been reached. In both cases the remaining space is filled with as much as possible MAC cells. This is done in the instructions 64 and 65. In instruction 64 it is checked whether there is still space available, by comparing the variable "offset" with the variable "ref". If there is still space available ("offset" < "ref") the next MAC cell is placed, and the variables "offset" and "i_mac" are incremented. Finally the counter i_block is increased by 1, and the program is continued at instruction 51.

CLAIMS

1. Transmission system comprising at least one transmitter coupled to at least one receiver, said transmitter comprises frame assembly means for assembling means for assembling frames from synchronous data portions and asynchronous data portions, the transmitter further, comprises transmitting means for transmitting the frames to at least one receiver, characterized in that the frame assembling means are arranged to insert the synchronous data at positions differing from their nominal positions in order to increase the efficiency of placing the asynchronous data in the frames.

2. Transmission system according to claim 1, characterized in that the frames comprises a plurality of elementary data cells, in that the synchronous data portions are carried by a first integer number of elementary data cells, and in that the asynchronous data portions are carried by a second integer number of elementary data cells.

3. Transmission system according to claim 2, characterized in that the elementary data cells comprise a data portion type identification.

4. Transmission system according to claim 2, characterized in that a number of elementary data cells comprise information about the constitution of the frames.

5. Transmitter comprising frame assembly means for assembling frames from synchronous data portions and asynchronous data portions, the transmitter further, comprises transmitting means for transmitting the frames, characterized in that the frame assembling means are arranged to insert the synchronous data at positions differing from their nominal positions in order to increase the efficiency of placing the asynchronous data in the frames.

6. Receiver for receiving frames comprising synchronous data portions and asynchronous data portions, characterized in that the receiver comprises frame disassembling means for retrieving synchronous data from positions in the frame differing from their nominal positions.

7. Transmission method comprising assembling frames from synchronous data portions and asynchronous data portions and transmitting the frames to at least one receiver, characterized in that the method comprises inserting the synchronous data portions at positions differing from their nominal positions in order to increase the efficiency of

placing the asynchronous data in the frames.

8. Method for receiving frames comprising synchronous data portions and asynchronous data portions, characterized in that the receiver comprises frame disassembling means for retrieving synchronous data from positions in the frame differing from their nominal positions.

9. Signal comprising frames from synchronous data portions and asynchronous data portions, characterized in that the synchronous data is present at positions differing from their nominal positions in order to increase the efficiency of placing the asynchronous data in the frames.

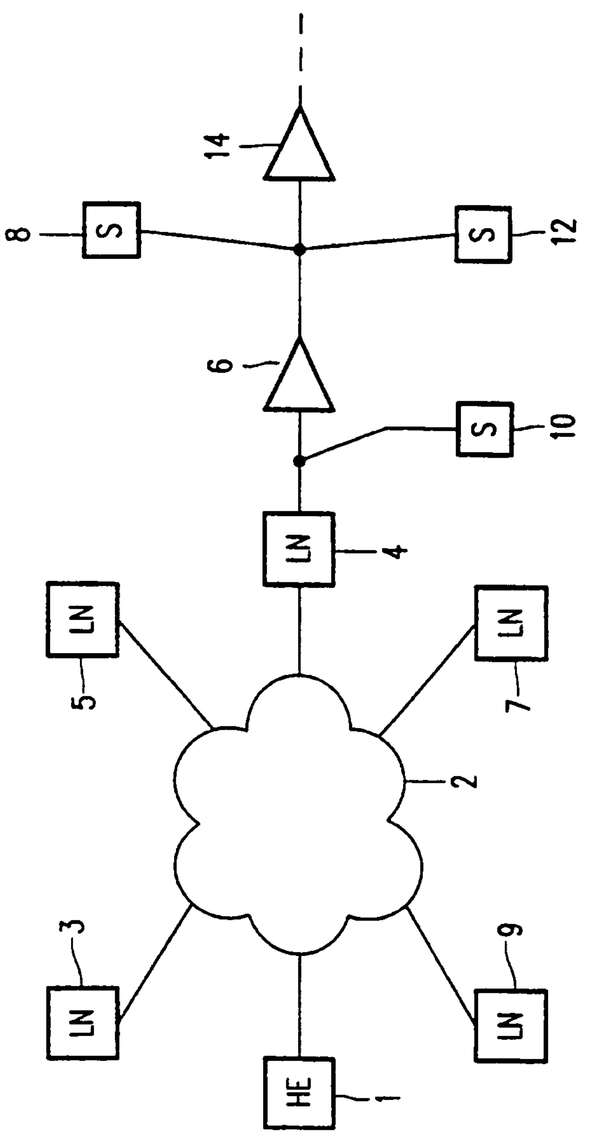

FIG. 1

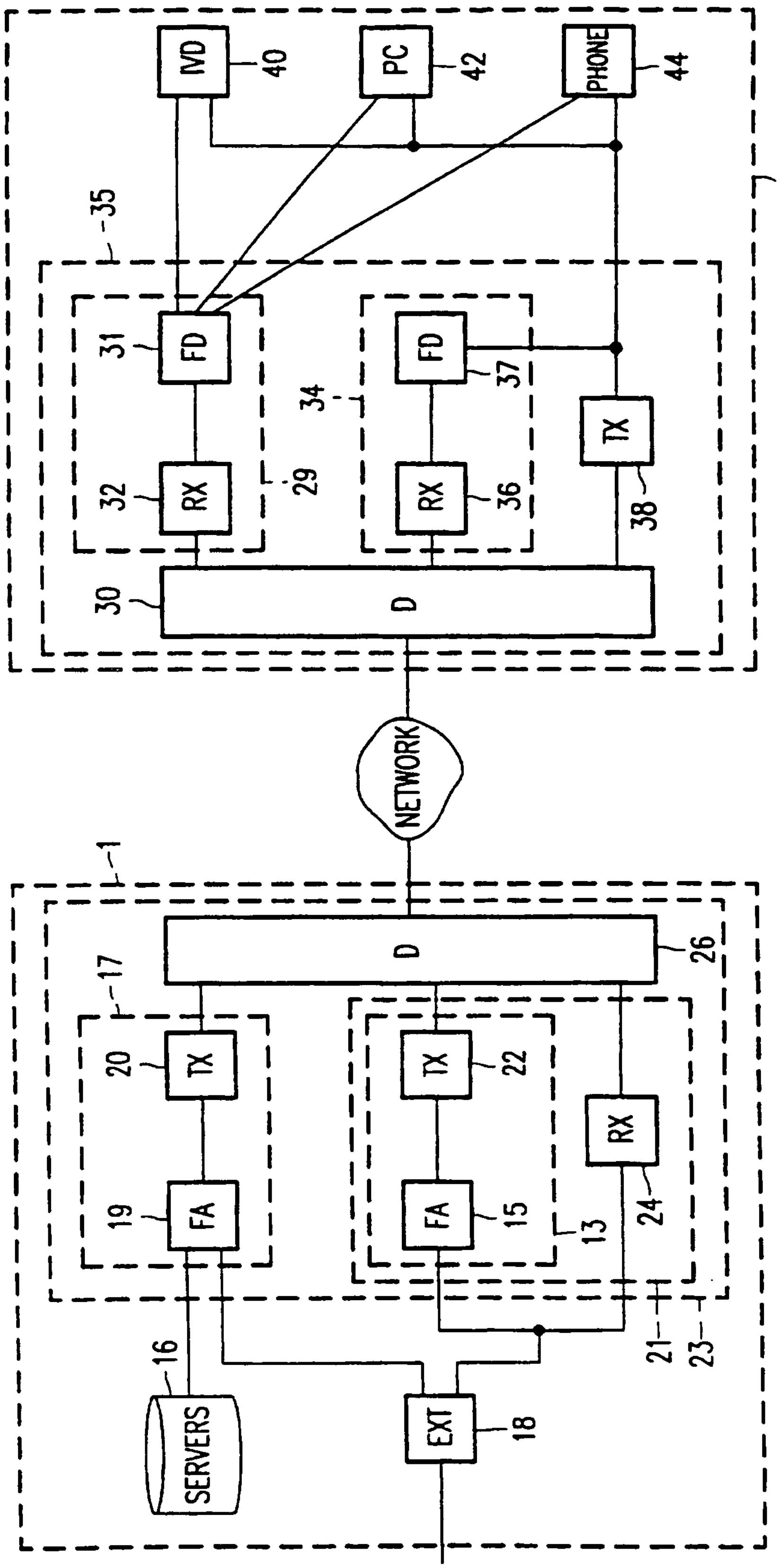
IVD
40
PC
42
PHONE
44
8,10,12
35
FD
31
RX
32
29
34
FD
37
RX
36
TX
38
D
30
NETWORK
D
26
17
TX
20
FA
19
TX
22
FA
15
13
RX
24
21
23
1
SERVERS
16
EXT
18

FIG. 2

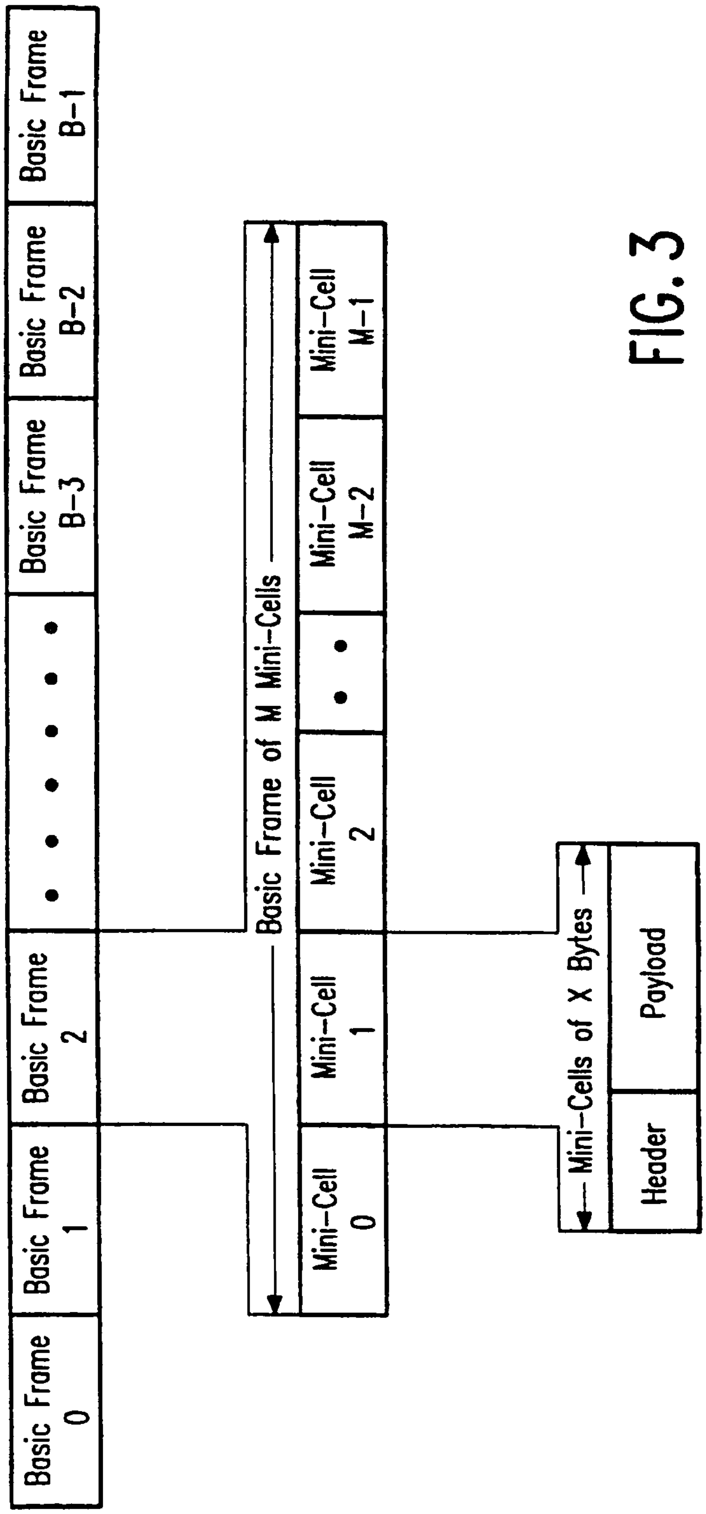
Basic Frame 0
Basic Frame 1
Basic Frame 2
Basic Frame B-3
Basic Frame B-2
Basic Frame B-1
Basic Frame of M Mini-Cells
Mini-Cell 0
Mini-Cell 1
Mini-Cell 2
Mini-Cell M-2
Mini-Cell M-1
Mini-Cells of X Bytes
Header
Payload

FIG. 3

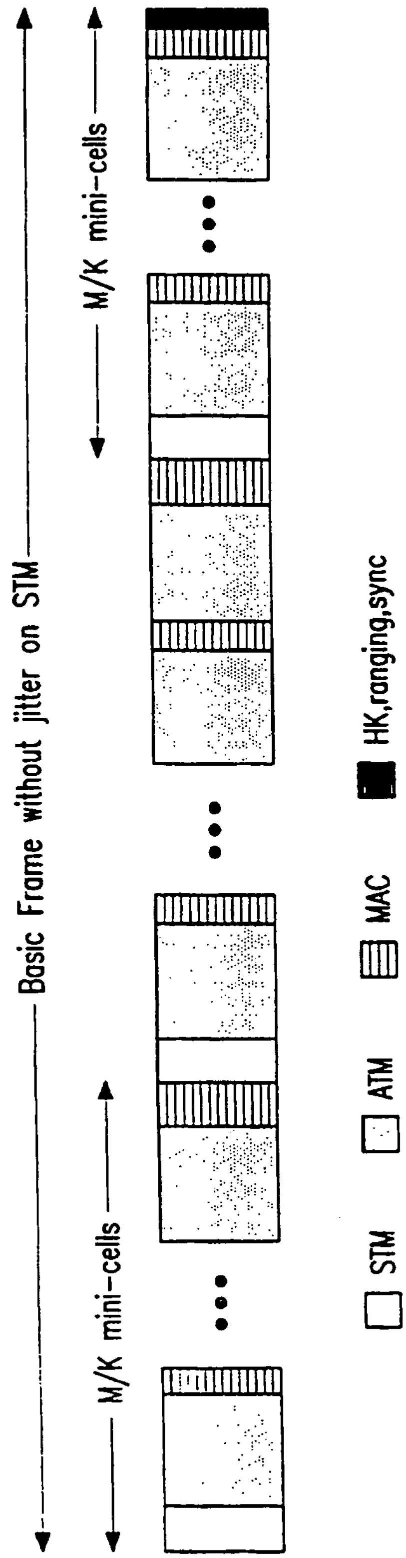
Basic Frame without jitter on STM
M/K mini-cells
M/K mini-cells
STM
ATM
MAC
HK,ranging,sync

FIG. 4

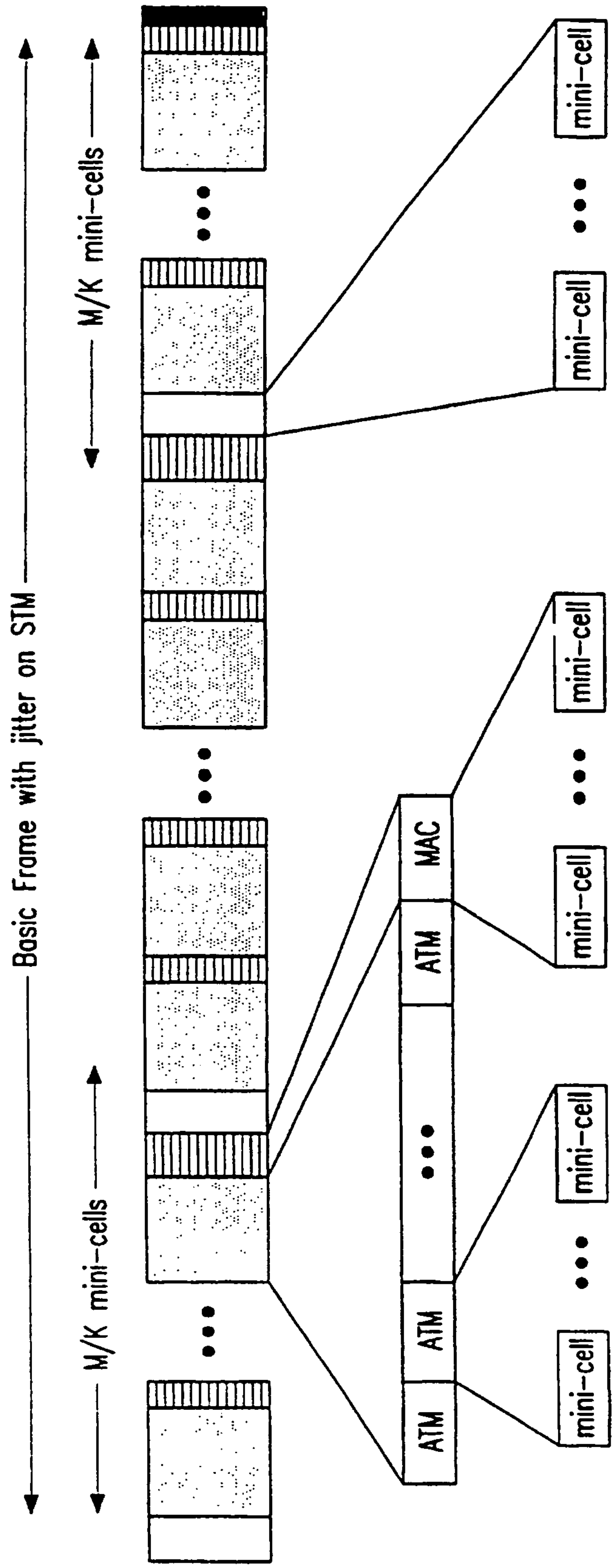
Basic Frame with jitter on STM
M/K mini-cells
M/K mini-cells
mini-cell
mini-cell
mini-cell
mini-cell
mini-cell
mini-cell
ATM
ATM
ATM
MAC

FIG. 5

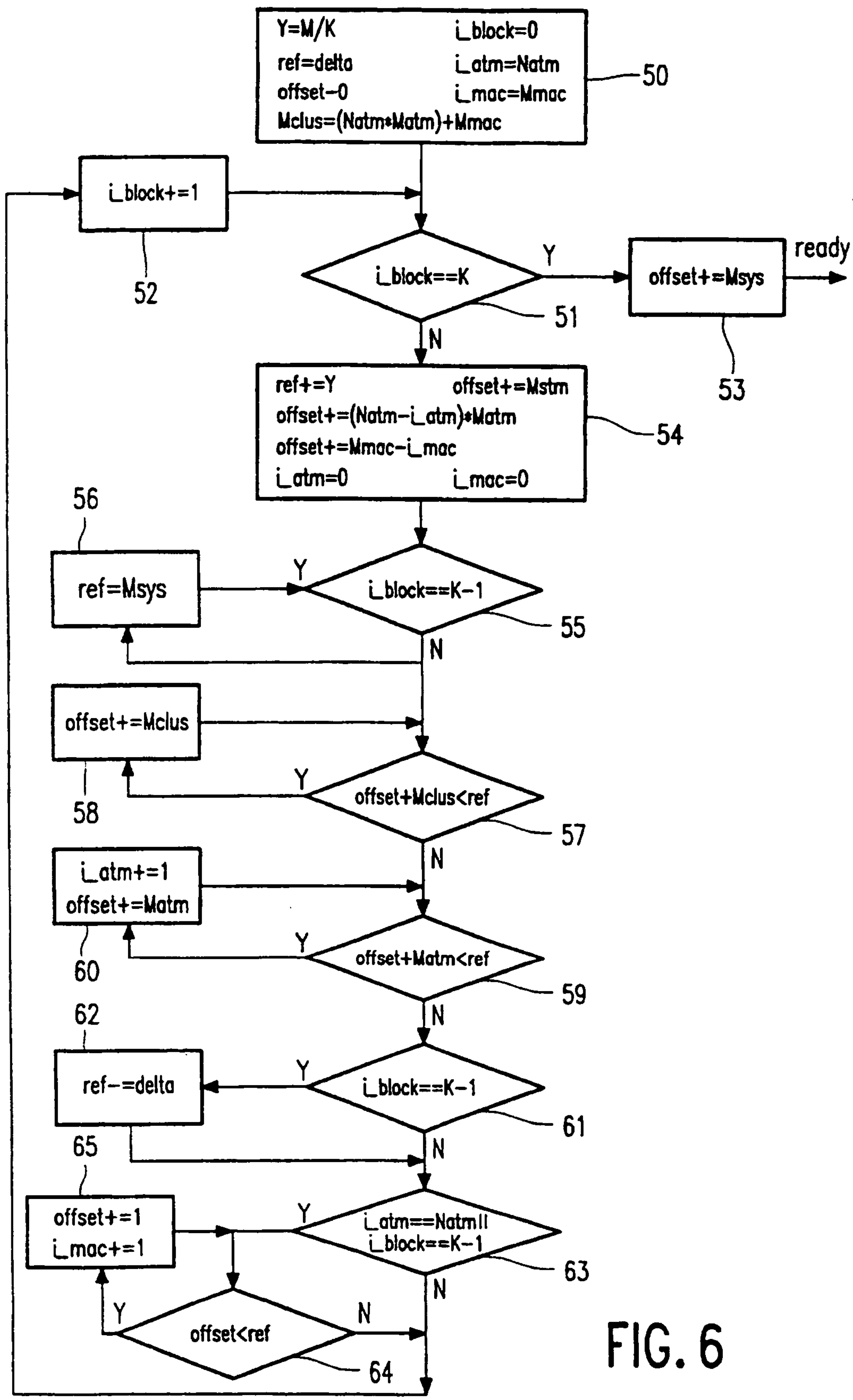
Y=M/K
i_block=0
ref=delta
i_atm=Natm
offset-0
i_mac=Mmac
Mclus=(Natm*Matm)+Mmac
50
i_block+=1
52
i_block==K
51
Y
offset+=Msys
53
ready
N
ref+=Y
offset+=Mstm
offset+=(Natm-i_atm)*Matm
offset+=Mmac-i_mac
i_atm=0
i_mac=0
54
56
ref=Msys
Y
i_block==K-1
55
N
offset+=Mclus
58
Y
offset+Mclus<ref
57
N
i_atm+=1
offset+=Matm
60
Y
offset+Matm<ref
59
N
62
ref-=delta
Y
i_block==K-1
61
N
65
offset+=1
i_mac+=1
Y
i_atm==Natm||
i_block==K-1
63
N
Y
offset<ref
N
64

FIG. 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 96/00878

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04J 3/16, H04L 12/56
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04J, H04L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5327428 A (VAN AS ET AL), 5 July 1994 (05.07.94), column 10, line 56 - column 11, line 21; column 28, line 8 - line 56 --	1,5-9
X	US 3988545 A (KUEMMERLE ET AL), 26 October 1976 (26.10.76), column 2, line 3 - line 63; column 7, line 19 - column 8, line 15 --	1,5-9
A	US 4494232 A (DAMBRACKAS ET AL), 15 January 1985 (15.01.85), column 1, line 65 - column 2, line 10; column 21, line 19 - line 42 --	1-9

[X] Further documents are listed in the continuation of Box C. [X] See patent family annex.

* Special categories of cited documents:

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Date of the actual completion of the international search	Date of mailing of the international search report
17 February 1997	18 -02- 1997

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 96/00878

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4093823 A (CHU), 6 June 1978 (06.06.78), column 5, line 36 - line 62	1-9

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INTERNATIONAL SEARCH REPORT

03/02/97

International application No.
PCT/IB 96/00878

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